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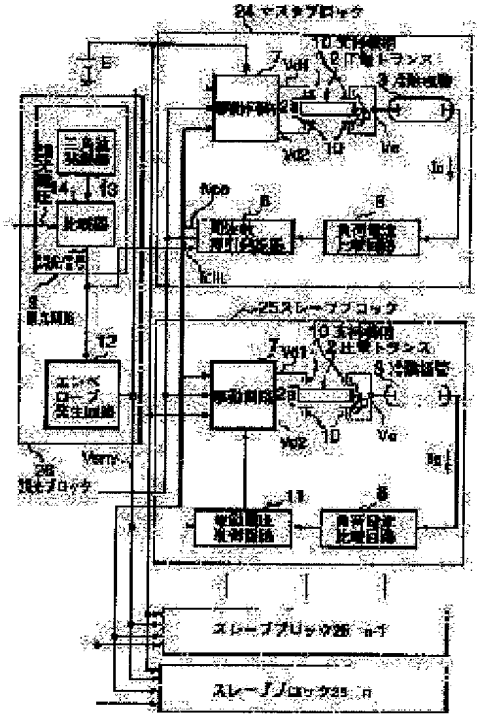
(54) INVERTER AND ITS DRIVING METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To eliminate a limit of the number of lighting tubes and tilt of luminosity and prevent flicker or audible sound from occurring, when plural cold cathode-ray tubes are driven using a piezoelectric trans-inverter.

SOLUTION: The inverter has at least one or more blocks of a master block 24 which includes a driving frequency controller for controlling frequency of driving voltage for a piezoelectric transformer and a slave block 25 into which signals from the driving frequency controller which has a driving voltage controller for controlling wave height of driving voltage for the piezoelectric transformer are entered, a means which modulates driving voltage impressed on the piezoelectric transformer with PWM and drives it at the same phase, and a means which suppresses higher harmonics of diminishing frequency contained in driving voltage of the piezoelectric transformer.



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CLAIMS

[Claim(s)]
[Claim 1] It has the driving means which changes direct current voltage into alternating voltage, and a pressure-up means to output as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary side from the secondary. In the drive approach of an inverter of driving the simple substance inverter which drives a primary said pressure-up means side with the alternating voltage of said driving means, and drives a load by the alternating current outputted from the secondary of said pressure-up means to two or more juxtaposition The drive approach of the inverter characterized by controlling the alternating current outputted from the secondary of said pressure-up means to constant value, and driving identically each drive frequency of said simple substance inverter.
[Claim 2] The driving means which changes direct current voltage into alternating voltage, and a pressure-up means to output as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary side from the secondary, In the drive approach of an inverter of driving the simple substance inverter which drives a primary said pressure-up means side with the alternating voltage of said driving means, and drives a load by the alternating current outputted from the secondary of said pressure-up means to two or more juxtaposition Control the alternating current outputted from the secondary of said pressure-up means to constant value, and the alternating voltage impressed to said load is controlled by PWM. The drive approach of the inverter characterized by making into the same phase the output period of said alternating voltage outputted from said each pressure-up means of said simple substance inverter, and driving it.
[Claim 3] The driving means which changes direct current voltage into alternating voltage, and a pressure-up means to output as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary side from the secondary, In the drive approach of an inverter of driving the simple substance inverter which drives a primary said pressure-up means side with the alternating voltage of said driving means, and drives a load by the alternating current outputted from the secondary of said pressure-up means to two or more juxtaposition Control the alternating current outputted from the secondary of said pressure-up means to constant value, and each drive frequency of said simple substance inverter is made the same. The drive approach of the inverter characterized by making into the same phase the output period of said alternating voltage which controls by PWM the alternating voltage impressed to said load, and is outputted from said each pressure-up means of said simple substance inverter, and driving it.
[Claim 4] Claims 1 and 2 characterized by making the same all the alternating current values that flow for said two or more loads, and driving them, or the drive approach of an inverter given in three.
[Claim 5] The drive approach of the inverter according to claim 2 or 3 characterized by oppressing and driving the higher harmonic wave by the PWM frequency contained in the alternating voltage impressed to said two or more pressure-up means.
[Claim 6] Claims 1, 3, and 4 characterized by said load being a cold cathode tube, or the drive approach of an inverter given in five.
[Claim 7] The driving means which changes direct current voltage into alternating voltage, and the

piezoelectric transformer outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary lateral electrode using the piezo-electric effect from the secondary electrode, The primary lateral electrode of said piezoelectric transformer is driven with the alternating voltage of said driving means. The alternating voltage outputted from the secondary electrode of said piezoelectric transformer is impressed to a load. In the drive approach of a piezoelectric transformer of operating the simple substance inverter which controls the current which carries out adjustable [of the drive frequency of said piezoelectric transformer], and flows for said load to constant value to two or more juxtaposition The drive approach of the piezoelectric transformer characterized by making the same each drive frequency of said simple substance inverter, and driving it.

[Claim 8] The driving means which changes direct current voltage into alternating voltage, and the piezoelectric transformer outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary lateral electrode using the piezo-electric effect from the secondary electrode, The primary lateral electrode of said piezoelectric transformer is driven with the alternating voltage of said driving means. The alternating voltage outputted from the secondary electrode of said piezoelectric transformer is impressed to a load. In the drive approach of a piezoelectric transformer of operating the simple substance inverter which controls the current which carries out adjustable [of the drive frequency of said piezoelectric transformer], and flows for said load to constant value to two or more juxtaposition The drive approach of the piezoelectric transformer characterized by making into the same phase the output period of said alternating voltage which controls by PWM the alternating voltage impressed to said load, and said each piezoelectric transformer of said simple substance inverter outputs, and driving it.

[Claim 9] The driving means which changes direct current voltage into alternating voltage, and the piezoelectric transformer outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary lateral electrode using the piezo-electric effect from the secondary electrode, The primary lateral electrode of said piezoelectric transformer is driven with the alternating voltage of said driving means. The alternating voltage outputted from the secondary electrode of said piezoelectric transformer is impressed to a load. In the drive approach of a piezoelectric transformer of operating the simple substance inverter which controls the current which carries out adjustable [of the drive frequency of said piezoelectric transformer], and flows for said load to constant value to two or more juxtaposition Control by PWM the alternating voltage impressed to said load, and each drive frequency of said simple substance inverter is made the same. The drive approach of the piezoelectric transformer characterized by making into the same phase the output period of said alternating voltage which said piezoelectric transformer of said simple substance inverter outputs in each, and furthermore driving it.

[Claim 10] Claims 7 and 8 characterized by making the same all the alternating current values that flow for said two or more loads, and driving them, or the drive approach of a piezoelectric transformer given in nine.

[Claim 11] Claims 7, 8, and 9 characterized by oppressing and driving the higher harmonic by the PWM frequency contained in the alternating voltage impressed to said two or more piezoelectric transformers, or the drive approach of a piezoelectric transformer given in ten.

[Claim 12] Claims 7, 8, 9, and 10 characterized by said load being a cold cathode tube, or the drive approach of a piezoelectric transformer given in 11.

[Claim 13] The 1st drive circuit which changes direct current voltage into alternating voltage, and the 1st piezoelectric transformer outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary lateral electrode using the piezo-electric effect from the secondary electrode, The frequency-sweep oscillator which outputs the drive frequency of said 1st piezoelectric transformer to said 1st drive circuit, It has the 1st load current comparator circuit which compares the size of a current which flows for the 1st load connected to said 1st piezoelectric transformer. It has the 1st inverter constituted so that the drive frequency of said frequency-sweep oscillator might be controlled by the control signal of said 1st load current comparator circuit and the alternating current value of the 1st load might be controlled by it to constant value. The 2nd drive circuit

to which the drive frequency which said frequency-sweep oscillator outputs is supplied, The 2nd load current comparator circuit which compares the size of a current which flows for the 2nd piezoelectric transformer connected to the 2nd drive circuit, and the 2nd load connected to said 2nd piezoelectric transformer, Have the driver voltage control circuit which carries out adjustable [of the driver voltage of the 2nd piezoelectric transformer which said 2nd drive circuit outputs], and said driver voltage control circuit is controlled by the control signal of said 2nd load current comparator circuit. The drive circuit of the piezoelectric transformer characterized by having 2nd at least one or more inverters constituted so that the alternating current value of the 2nd load might be controlled to constant value.

[Claim 14] The drive circuit of the piezoelectric transformer according to claim 13 characterized by having the means which carries out adjustable [of the alternating current which impresses the driver voltages of said the 1st and said 2nd piezoelectric transformer to said the 1st and said 2nd load with the output signal of a modulated light circuit because it is intermittent with the same phase with PWM].

[Claim 15] The drive circuit which changes direct current voltage into alternating voltage, and the piezoelectric transformer outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary lateral electrode using the piezo-electric effect from the secondary electrode, The frequency-sweep oscillator which outputs the drive frequency of said piezoelectric transformer to said drive circuit, The load current comparator circuit which compares the size of a current which flows for the load connected to said piezoelectric transformer, The inverter constituted so that the drive frequency of said frequency-sweep oscillator might be controlled by the control signal of said load current comparator circuit and the alternating current value of a load might be controlled by it to constant value is connected to or more at least two juxtaposition. The drive circuit of the piezoelectric transformer characterized by carrying out adjustable [of the alternating current which impresses of said two or more loads in each] with the output signal of a modulated light circuit by being intermittent with the same phase in the driver voltage of two or more of said piezoelectric transformers of each with PWM.

[Claim 16] Claims 13 and 14 characterized by having a means to control identically all the alternating current values that flow said two or more loads, respectively, or the drive circuit of a piezoelectric transformer given in 15.

[Claim 17] Claims 13, 14, and 15 characterized by having the EMBE lobe generating circuit which modulates the envelope of a drive wave of the driver voltage of two or more of said piezoelectric transformers, and a means to oppress the harmonic content of drive frequency, or the drive circuit of a piezoelectric transformer given in 16.

[Claim 18] Claims 13, 14, 15, and 16 characterized by said load being a cold cathode tube, or the drive circuit of a piezoelectric transformer given in 17.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates the cold cathode tube used as a load about an inverter and its drive approach to the drive circuit and its drive approach of plurality and the piezoelectric transformer which suppressed generating of audible sound while switching on stability efficiently.
[0002]
[Description of the Prior Art] Generally a piezoelectric transformer is a component which takes out the electrical potential difference which carried out the pressure up of the mechanical oscillation to the secondary electrode from a lifting and this mechanical oscillation by impressing the alternating voltage of resonance frequency and resonating it to a primary lateral electrode. this -- electromagnetism -- it has the description which can attain miniaturization and thin shape-ization as compared with a transformer, and is observed by applications, such as a back light power source of the indicating equipment by liquid crystal. A piezoelectric transformer has the property that a pressure-up ratio changes with the impedances of a load, like the pressure-up property shown in drawing 9 . Moreover, a cold cathode tube has the property that the high voltage is needed, in order to start discharge, as shown in drawing 10 . In this case, the impedance seen from the piezoelectric transformer becomes very large. next, if discharge starting is carried out and the tube electric current begins to flow, the impedance of a cold cathode tube will fall, the electrical potential difference of a cold cathode tube will decrease rapidly, but when a until current flows to some extent, there is a property that reduction in an electrical potential difference becomes loose. Therefore, a piezoelectric transformer is a component with the property suitable for driving a cold cathode tube [say / that a pressure-up ratio falls], when a cold cathode tube is used as a load, a high pressure-up ratio is obtained at the time of lighting initiation, the tube electric current flows and lighting is stabilized.
[0003] Conventionally, as the drive circuit of this kind of piezoelectric transformer is shown in JP,8-45679,A, the circuit which performs two or more series lighting in one piezoelectric transformer is known in the cold cathode tube used as a load of a piezoelectric transformer. This circuit is shown in drawing 11 . DC power supply E by which this circuit supplies power to the inverter 1 which changes a direct current into the alternating current of high frequency, and an inverter 1 The piezoelectric transformer 2 which outputs the high-pressure alternating voltage Vo by which inputted alternating voltage into primary lateral electrode 2a, and the pressure up was carried out from secondary electrode 2b using the piezo-electric effect, The cold cathode tube 3 by which two or more series connection was carried out to secondary electrode 2b of a piezoelectric transformer 2 as a load, It consists of an integrator 4 which consists of diode D which rectifies the resistance R for tube electric current Io detection, and alternating voltage, and a smoothing circuit, and V-F converter 5 which controls the resonance frequency f of an inverter 1 by the integrator 4 based on the electrical potential difference by which smooth was carried out.
[0004] Next, actuation in the conventional example of drawing 11 is explained. The direct current

voltage supplied from DC power supply E is changed into alternating voltage in an inverter 1. The alternating voltage of the changed frequency f will be outputted as alternating voltage Vo of the high-pressure frequency f in which the pressure up was carried out by the piezo-electric effect from secondary electrode 2b, if inputted into primary lateral electrode 2a of a piezoelectric transformer 2. Although the alternating voltage Vo of this high-pressure frequency f is inputted into the cold cathode tube 3 by which two or more series connection was carried out as a load of a piezoelectric transformer 2, the tube electric current Io which flows for a load at this time is changed into alternating voltage by Resistance R, and becomes the electrical potential difference by which smooth was carried out with the integrator 4 after rectification for Diode D. Based on the electrical potential difference by which smooth was carried out with this integrator 4, V-F converter 5 is controlling the resonance frequency f of an inverter 1 and changing the pressure-up ratio of a piezoelectric transformer, and supplies the predetermined tube electric current Io to a load. Series lighting of the cold cathode tube 3 by which two or more series connection was carried out in the cold cathode tube drive circuit by the above circuitry is performed.

[0005] As a conventional example of further others, as shown in drawing 12 , there is a circuit which performs juxtaposition lighting of two or more by making one cold cathode tube used as a load of a piezoelectric transformer turn on with one piezoelectric transformer. The support device 10 in which the circuit of this drawing 12 supports physically a piezoelectric transformer 2 and this piezoelectric transformer 2, The drive circuit 7 which changes direct current voltage into the half wave sinusoidal voltage of two phases generated by turns, and outputs it to the two electrodes of primary lateral electrode 2a of a piezoelectric transformer 2 by turns, DC power supply E which supply power to the drive circuit 7, and the frequency-sweep oscillator 6 which controls the frequency fk of the half wave sinusoidal voltage of two phases of the drive circuit 7, The cold cathode tube 3 connected to secondary electrode 2b of a piezoelectric transformer 2, and the load current comparator circuit 8 which controls the direction of a frequency sweep of the frequency-sweep oscillator 6 by comparing with a reference value the tube electric current Io which flows to a cold cathode tube 3, It consists of modulated light circuits 9 which output the modulated light signal for carrying out the time-sharing drive of the piezoelectric transformer 2 to the frequency-sweep oscillator 6 and the drive circuit 7.

[0006] Next, actuation of the conventional example of this drawing 12 is explained. The direct current voltage supplied from DC power supply E is changed into the half wave sinusoidal voltage of two phases in the drive circuit 7, and it is outputted as a high-pressure sinusoidal voltage Vo in which the pressure up was carried out by the piezo-electric effect from secondary electrode 2b in inputting into the two electrodes of primary lateral electrode 2a of a piezoelectric transformer 2 by turns. This high-pressure sinusoidal voltage Vo is inputted into the cold cathode tube 3 connected as a load of a piezoelectric transformer 2. The tube electric current Io which flows for a load at this time is inputted into the load current comparator circuit 8, and is compared with the reference value of the load current comparator circuit 8 interior. When the tube electric current Io is smaller than a reference value, the signal to which the frequency fk of the half wave sinusoidal voltage of two phases which are the outputs of the drive circuit 7 is reduced to the frequency-sweep oscillator 6 is outputted, and when the tube electric current Io is large, the signal which raises a frequency fk is outputted. And the frequency-sweep oscillator 6 outputs the driving signal of a frequency fk to the drive circuit 7 based on the signal from the load current comparator circuit 8. Then, the drive circuit 7 drives a piezoelectric transformer 2 with the half wave sinusoidal voltage of the frequency fk of two phases. Thus, the drive frequency fk of a piezoelectric transformer 2 can be controlled, and the predetermined tube electric current Io can be supplied to a load by changing the pressure-up ratio of a piezoelectric transformer.

[0007] Next, a modulated light part is explained. The modulated light circuit 9 is lower than the drive frequency fk of a piezoelectric transformer 2 enough, and outputs the binary modulated light signal with which it oscillates and a duty ratio changes in proportion to the inputted modulated light electrical potential difference on the frequency fc which does not sense a flicker for an eye to the frequency-sweep oscillator 6 and the drive circuit 7. If this modulated light signal becomes high-level, the drive circuit 7 will stop the drive of a piezoelectric transformer 2, and will stop the tube electric current Io which flows for a load. While the tube electric current Io has stopped so that it may not change with actuation of the

load current comparator circuit 8 to the one where drive frequency fk is lower, the frequency-sweep oscillator 6 operates so that the drive frequency fk before a tube electric current Io halt may be held. Next, when a modulated light signal is set to a low level, the drive circuit 7 resumes the drive of a piezoelectric transformer 2 and the tube electric current Io begins to flow, it can be made to function as the tube electric current Io not changing.

[0008] The wave of operation by the conventional technique of this drawing 12 is shown in drawing 13 . The modulated light signal which is the output of the modulated light circuit 9 is set to high level and a low level with the period of a frequency fc. Since the output of the half wave sinusoidal voltage of the frequency fk of two phases which are the driver voltages of a piezoelectric transformer 2 is suspended, the sinusoidal voltage Vo of the high-pressure frequency fk is not outputted from a piezoelectric transformer 2, but a high-level period also stops the tube electric current Io which flows for a load. Actuation which always makes a modulated light signal a low level for making the brightness of a cold cathode tube 3 into max, and lengthens a period high-level for reducing brightness is performed. Thus, the Pulse-Density-Modulation PWM (Pulse Width Modulation) method which modulates the light by changing the time interval of the tube electric current Io passed to a cold cathode tube 3 by changing the duty ratio of the modulated light signal which is the output of the modulated light circuit 9 is used.

[0009] In the conventional technique of drawing 12 , juxtaposition lighting of two or more cold cathode tubes 3 used as a load is performed by using two or more piezoelectric transformer inverters by the above circuitry.

[0010]

[Problem(s) to be Solved by the Invention] However, there are the following troubles in JP,8-45679,A and the technique shown in drawing 12 .

[0011] The first trouble is that the number of cold cathode tubes connectable with a serial is restricted, when two or more series lighting of the cold cathode tube 3 is carried out as a load of a piezoelectric transformer 2. When the property Fig. of the mechanical oscillation rate vm to the output power Pout of the piezoelectric transformer 2 shown in drawing 14 (a) is seen, it turns out that the power Pout which can output a piezoelectric transformer 2 is proportional to the mechanical oscillation rate vm mostly. In order to turn on a cold cathode tube 3 to a two or more serial, power required to turn on one cold cathode tube.3 is needed by the number. While temperature rise deltaT from ambient temperature increases like drawing 14 (b) if this output power is enlarged although it is necessary to enlarge the mechanical oscillation rate vm in order to make larger power output from a piezoelectric transformer 2, the effectiveness eta shown in drawing 14 (c) will decrease. And when the mechanical oscillation rate vm is set even to vml, temperature rise deltaT begins to increase rapidly and there is an inclination for effectiveness eta to decrease rapidly. It can be used as an efficient piezoelectric transformer inverter after point delta T1 and the point eta 1 that effectiveness eta decreases rapidly which this temperature rise deltaT increases rapidly. Therefore, it can be said that this temperature rise deltaT1 and the output power Pout1 used as the effectiveness eta1 neighborhood are the threshold value of the output power Pout of the piezoelectric transformer 2 in an efficient piezoelectric transformer inverter. For example, when the cold cathode tube 3 of die length of 360mm from which the piezoelectric-device configuration of a piezoelectric transformer 2 serves as a load in a thing with die length of 42mm, a width of face [of 10mm], and a thickness of 1mm, and tube diameter 3phi is driven by tube electric current Io=4.4mArms, the output power threshold value Pout1 of a piezoelectric transformer 2 is 7W. Since the output power Pout of the piezoelectric transformer 2 at the time of driving one of said cold cathode tube 3 is about 3.5W, as for the number which can connect said cold cathode tube 3 to said piezoelectric transformer 2 at a serial, two are a limitation. As mentioned above, when using a tube length's long cold cathode tube 3 for a two or more multi-LGT type back light with big-screen-izing of a liquid crystal panel, the degree of freedom of the series connection of a cold cathode tube decreases, and there is no room of selection as a matter of fact.

[0012] The second trouble is that brightness becomes an ununiformity, when two or more series lighting of the cold cathode tube 3 is carried out as a load of a piezoelectric transformer 2. If the reason has a conductive reflecting plate etc. around a cold cathode tube 3, it will be because stray capacity is formed

between a cold cathode tube 3 and its reflecting plate. Although the high voltage electrode side of a cold cathode tube 3 is large and the tube electric current value of brightness is high since a current flows to this formed stray capacity, in a low voltage electrode side, a tube electric current value decreases and brightness falls. This phenomenon tends to become still more remarkable when a cold cathode tube 3 is connected to a two or more serial, since the stray capacity formed, so that the tube length of a cold cathode tube 3 is long becomes large.

[0013] The third trouble is that reach, or a flicker by interference between cold cathode tube 3 occurs since each modulated light frequency fc is asynchronous each drive frequency fk, when two or more juxtaposition lighting of the cold cathode tube 3 is carried out as a load of a piezoelectric transformer 2. Since the swept frequency generation oscillator 6 exists in each piezoelectric transformer inverter, even when dispersion is in the pressure-up property of the piezoelectric transformer 2 of drawing 9 , or the voltage-current property of the cold cathode tube 3 of drawing 10 , the tube electric current Io which flows to each cold cathode tube 3 by changing drive frequency fk is altogether made into the fixed predetermined value. For this reason, by coupling of cold cathode tube 3 being carried out by the stray capacity generated in both cold cathode tube 3, since it becomes the frequency from which drive frequency fk differed in each piezoelectric transformer inverter, as shown in drawing 15 , amplitude modulation of the tube electric current Io will be carried out. When modulated light by PWM is applied in this condition, and brightness was reduced, and it became below a certain brightness, there was a problem which a flicker generates. The high pressure at the time of drive initiation and a halt of a piezoelectric transformer 2 moreover, by changing the tube electric current value which flows other cold cathode tubes 3 by coupling according that each modulated light frequency fc is asynchronous to the stray capacity of cold cathode tube 3 Actuation of the load current comparator circuit 8 which is controlling drive frequency fk, and a circuit called the swept frequency generation oscillator 6 is influenced so that the tube electric current Io may be made regularity, and the problem to which the actuation as an inverter becomes unstable occurs.

[0014] The fourth trouble is that generating of audible sound increases, when a two or more serial is made to turn on a tube length's long cold cathode tube 3 as a load of a piezoelectric transformer 2. When modulated light according a piezoelectric transformer 2 to PWM is performed, since the driver voltage of a piezoelectric transformer 2 becomes a burst wave like driver voltage Vd shown in drawing 13 , the higher harmonic of the modulated light frequency fc is included in drive frequency fk at the time of drive initiation or a halt. If a piezoelectric transformer 2 is driven by the driver voltage Vd of the drive frequency fk in which this higher harmonic was included, the vibrational state of a piezoelectric transformer 2 will be in the condition of having been confused momentarily, at the time of drive initiation or a halt, and the phenomenon in which vibration gets across to the support device 10 of a piezoelectric transformer 2 will occur. This serves as vibration of a piezoelectric transformer 2 or the support device 10, and becomes the cause of generating audible sound. When driving a tube length's short cold cathode tube 3, even if generating of audible sound is low, in driving a tube length's long cold cathode tube 3 to a two or more serial, the breakdown voltage and tube voltage of the cold cathode tube 3 made to turn on become high, and since the mechanical oscillation rate vm of a piezoelectric transformer 2 increases, it is easy to generate audible sound.

[0015] The purpose of this invention is by synchronizing two or more drive frequencies and modulated light frequencies of an inverter to offer the drive circuit of the piezoelectric transformer which makes stability turn on two or more cold cathode tubes efficiently. Moreover, it is in offering the drive circuit of the piezoelectric transformer which prevents generating of the audible sound which poses a problem at the time of modulated light of PWM in the inverter which makes two or more cold cathode tubes turn on.

[0016]

[Means for Solving the Problem] The 1st drive circuit where the concrete means of the inverter of this invention changes direct current voltage into alternating voltage, The 1st piezoelectric transformer outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted from the primary lateral electrode using the piezo-electric effect from the secondary electrode, The

frequency-sweep oscillator which outputs the drive frequency of said 1st piezoelectric transformer to said 1st drive circuit, It has the 1st load current comparator circuit which compares the size of a current which flows for the 1st load connected to said 1st piezoelectric transformer. It has the 1st inverter constituted so that the drive frequency of said frequency-sweep oscillator might be controlled by the control signal of said 1st load current comparator circuit and the alternating current value of the 1st load might be controlled by it to constant value. The 2nd drive circuit to which the drive frequency which said frequency-sweep oscillator outputs is supplied, The 2nd load current comparator circuit which compares the size of a current which flows for the 2nd piezoelectric transformer connected to the 2nd drive circuit, and the 2nd load connected to said 2nd piezoelectric transformer, Have the driver voltage control circuit which carries out adjustable [of the driver voltage of the 2nd piezoelectric transformer which said 2nd drive circuit outputs], and said driver voltage control circuit is controlled by the control signal of said 2nd load current comparator circuit. It is characterized by having 2nd at least one or more inverters constituted so that the alternating current value of the 2nd load might be controlled to constant value.

[0017] Moreover, it is characterized by having the EMBE lobe generating circuit which outputs the signal which oppresses the higher harmonic wave by the time-sharing drive included in the frequency component of drive frequency from the signal of the modulated light circuit which outputs the signal for modulating the driver voltage of the 1st and 2nd piezoelectric transformers by PWM to a swept frequency generation oscillator and an EMBE lobe generating circuit, and a modulated light circuit to the 1st drive circuit and driver voltage control circuit. Furthermore, it has a means (6 of drawing 1) to carry out the synchronous drive of the drive frequency of two or more piezoelectric transformers, a means (9 of drawing 1) to modulate the driver voltage of two or more piezoelectric transformers by PWM in phase, a means (11 of drawing 1) to control the tube electric current by controlling the peak value of the driver voltage of a piezoelectric transformer uniformly, and a means (12 of drawing 1) to modulate the envelope of the driver voltage of a piezoelectric transformer to a trapezoidal wave.

[0018] The drive circuit of the piezoelectric transformer of this invention carries out the synchronous drive of all the drive frequencies of a piezoelectric transformer. For this reason, since the amplitude modulation of the tube electric current by coupling of the stray capacity between cold cathode tubes can be lost, there is an operation which a flicker of a cold cathode tube does not generate. Moreover, since the synchronous drive of all the modulated light frequencies is carried out in an PWM modulated light method and it can prevent the high pressure at the time of drive initiation or a halt of a piezoelectric transformer not changing the tube electric current value which flows other cold cathode tubes by coupling by the stray capacity of cold cathode tubes, and inverter actuation becoming unstable, generating of a flicker is avoidable. Moreover, in a slave block, the peak value of the driver voltage of a piezoelectric transformer is controlled, and the tube electric current is controlled uniformly. For this reason, the synchronous drive of all the drive frequencies can be carried out, making all cold cathode tubes turn on by the same brightness. Moreover, the envelope of the driver voltage of the piezoelectric transformer at the time of modulated light is modulated to the trapezoidal wave. For this reason, when two or more juxtaposition is made to turn on a tube length's long cold cathode tube, increase of the audible sound which poses a problem can be reduced.

[0019]

[Embodiment of the Invention] Next, a drawing is computed about the gestalt of operation of this invention, and it explains to a detail. Drawing 1 is the block diagram of this example. General classification of the circuit of this drawing 1 constitutes it with the master block 24, the slave block 25, and the modulated light block 26.

[0020] First, the 1st piezoelectric transformer 2 outputted as alternating voltage which carried out the pressure up of the alternating voltage inputted into primary lateral electrode 2a from secondary electrode 2b as the master block 24 was shown in drawing 3 , The 1st cold cathode tube 3 connected to secondary electrode 2b of the 1st piezoelectric transformer 2, The 1st drive circuit 7 which changes into the half wave sinusoidal voltage of two phases which generate direct current voltage by turns, and is outputted to the two electrodes of primary lateral electrode 2a of the 1st piezoelectric transformer 2 by turns, It

consists of the 1st load current comparator circuit 8 which outputs the signal which controls the direction of a frequency sweep of the tube electric current Io to the frequency-sweep oscillator 6 which controls the drive frequency fk of the 1st drive circuit 7, and the frequency-sweep oscillator 6 which flows to the 1st cold cathode tube 3. After the tube electric current Io which flows to the 1st cold cathode tube 3 inputted into the 1st load current comparator circuit 8 is changed into alternating voltage by the 1st current-electrical-potential-difference conversion circuit 17, it is changed into direct current voltage by the 1st rectifier circuit 18. And it is compared with the reference voltage Vref which calculates the predetermined value of the tube electric current Io by the 1st comparator 19. The output signal of the 1st comparator 19 outputs the signal which raises the drive frequency fk of the 1st piezoelectric transformer 2, when the direct current voltage obtained from the tube electric current Io to the frequency-sweep oscillator 6 is larger than reference voltage Vref. On the other hand, when direct current voltage is smaller than reference voltage Vref, the signal to which drive frequency fk is reduced is outputted. The frequency-sweep oscillator 6 which inputted this signal is an integrating circuit 21, changes the binary output signal of the 1st comparator 19 into the signal of an analog quantity, and outputs it to VCO22 and a comparator 20.

[0021] Although VCO22 which oscillates the frequency corresponding to the output signal of this analog quantity is an oscillator circuit which outputs drive frequency twice the frequency of fk, and this oscillation frequency falls so that the output voltage of an integrating circuit 21 becomes high When the output voltage and reference voltage Vmax of an integrating circuit 21 are compared and output voltage exceeds reference voltage Vmax in a comparator 20, That is, when it falls to the lowest frequency it is decided with reference voltage Vmax that an oscillation frequency will be, a reset signal will be outputted to an integrating circuit 21, and a sweep will be performed for the oscillation frequency of VCO22 at a high speed from lowest frequency to the highest frequency. VCO22 is a circuit which outputs two signals, the triangular wave fvco in the frequency range from this lowest frequency to the highest frequency, and a square wave fclk. The triangular wave fvco which is the output of this VCO22, and a square wave fclk are inputted into the 1st drive circuit 7. The 1st drive circuit 7 is carrying out dividing of the square wave fclk outputted from VCO22 of the frequency-sweep oscillator 6 by the 1st frequency divider 16, and generates the signal of two phases with which a duty ratio becomes 50%. When one of Q1 and Q2 turns on by inputting the signal of these two phases into the 1st transistor Q1 and Q2, and making Q1 and Q2 switch by turns, Current energy is stored in the 1st coil L1 and L2 connected to this transistor. By emitting the current energy stored when turned off as electrical-potential-difference energy by the series resonance of the input capacitance of the 1st coil and the 1st piezoelectric transformer 2, the half wave sinusoidal voltages Vd1 and Vd2 of the 1st two phase are generated. This half wave sinusoidal voltage is inputted into the two electrodes of primary lateral electrode 2a of the 1st piezoelectric transformer 2 by turns, and functions as a sinusoidal voltage equivalent. Then, the 1st piezoelectric transformer 2 is outputting output voltage Vo to secondary electrode 2b, and is making the 1st cold cathode tube 3 turn on by the pressure-up ratio according to the impedance of drive frequency fk and the 1st cold cathode tube 3.

[0022] Next, the slave block 25 is shown and explained to drawing 4 . It consists of driver voltage control circuits 11 which output the signal which controls the electrical-potential-difference peak value of the half wave sinusoidal voltage of two phases which are the outputs of the 2nd piezoelectric transformer 2, the 2nd cold cathode tube 3, the 2nd drive circuit 7, the 2nd load current comparator circuit 8, and the 2nd drive circuit 7. Since the 2nd load current comparator circuit 8 is the same configuration as the 1st load current comparator circuit 8, the tube electric current Io which flows to the 2nd cold cathode tube 3 outputs the binary signal which shows whether it is larger than the predetermined value decided by 2nd ****** Vref, or small. A signal binary [this] is inputted into the driver voltage control circuit 11, and is changed into the signal Vc of an analog quantity. And this signal Vc is inputted into the 2nd drive circuit 7. Since this 2nd drive circuit 7 is the same configuration as the 1st drive circuit 7, it generates the half wave sinusoidal voltages Vd1 and Vd2 of the 2nd two phase which drives the 2nd piezoelectric transformer 2. The output signal Vc of the driver voltage control circuit 11 inputted into this 2nd drive circuit 7 is inputted into the 2nd comparator 15, and is compared

with the triangular wave fvco outputted from VCO22 of the 1st frequency-sweep oscillator 6. And the 2nd comparator 15 outputs the signal which controls the 2nd transistor Q3. The peak value of the half wave sinusoidal voltages Vd1 and Vd2 of the 2nd two phase which drives the 2nd piezoelectric transformer 2 is controlled by changing ON of the 2nd transistor Q3, and the ratio of OFF with this output signal, and controlling the current value inputted into the 2nd coil L1 and L2. The example of an internal circuitry of this driver voltage control circuit 11 is shown in drawing 5 . For example, when the tube electric current Io which flows to the 2nd cold cathode tube 3 becomes larger than a predetermined value, a high-level signal is outputted from the 2nd comparator 19 of the 2nd load current comparator circuit 8. Since ON and SW2 turn off and SW1 is charged by Capacitor Ci through a constant current source in response to this high-level signal, the electrical potential difference Vi of Capacitor Ci increases. This electrical potential difference Vi is inputted into the reversal terminal of an integrating circuit 23, and Venv which is the output of the EMBE lobe generating circuit 12 is inputted into the noninverting terminal. This Venv serves as a signal with a cold cathode tube 3 high-level at the time of lighting, and when the electrical potential difference Vi of Capacitor Ci becomes high from Venv, the output Vc of an integrating circuit 23 declines. Since this Vc is compared with the triangular wave fvco which is the output of VCO22 of the frequency-sweep oscillator 6 which is inputted into the reversal terminal of the 2nd comparator 15 of the 2nd drive circuit 7, and was inputted into the noninverting terminal, if the output Vc of an integrating circuit 23 declines, a signal with which the duty of the period which turns off the 2nd transistor Q3 from the 2nd comparator 15 becomes large will be outputted. When the tube electric current Io becomes smaller than a predetermined value on the contrary, the signal of a low level is outputted from the 2nd comparator 19. Since OFF and SW2 turn [SW1] on in response to the signal of this low level and Capacitor Ci discharges through a constant current source, the electrical potential difference Vi of Capacitor Ci decreases. When this electrical potential difference Vi becomes lower than Venv, the output Vc of an integrating circuit 23 increases. An increment of the output Vc of an integrating circuit 23 outputs a signal with which the duty of the period which turns on the 2nd transistor Q3 from the 2nd comparator 15 becomes large.

[0023] This wave form chart of operation is shown in drawing 7 . The tube electric current Io which flows to the 2nd cold cathode tube 3 is controlled by controlling the peak value of the half wave sinusoidal voltages Vd1 and Vd2 of the 2nd two phase to the predetermined current value. In addition, since the square wave fclk which is the output of VCO22 of the frequency-sweep oscillator 6 is inputted into the frequency divider 16 of the 2nd drive circuit 7, the frequency of the half wave sinusoidal voltages Vd1 and Vd2 of this 2nd two phase is the frequency fk of the half wave sinusoidal voltages Vd1 and Vd2 of the 1st two phase, and the frequency which synchronized. Moreover, the slave block 25 can be connected to juxtaposition like drawing 1 , and n cold cathode tubes 3 can be made to turn on.

[0024] Next, the modulated light block 26 is explained. The modulated light circuit 9 which outputs a modulated light signal for the modulated light block 26 to control intermittently the 1st and 2nd piezoelectric transformers 2 by the modulated light frequency fc to the swept frequency generation oscillator 6 and the EMBE lobe generating circuit 12 in drawing 1 , It consists of EMBE lobe generating circuits 12 which output the signal which oppresses the higher harmonic generated by [which control intermittently] being contained in the frequency component of the driver voltages Vd1 and Vd2 of a piezoelectric transformer 2 to the 1st drive circuit 7 and driver voltage control circuit 11. The modulated light circuit 9 consists of a triangular wave oscillator 13 which oscillates the frequency which does not have a flicker in an eye low enough compared with drive frequency fk, and a comparator 14 which compares the triangular wave and modulated light electrical potential difference which are the output of this triangular wave oscillator 13, and determines the duty ratio of a modulated light signal. When the modulated light signal outputted from the modulated light circuit 9 has a modulated light electrical potential difference higher than a triangular wave, it is always a low level, but high-level duty becomes long gradually as a modulated light electrical potential difference falls. This modulated light signal is inputted into the integrating circuit 21 (refer to drawing 3) of the swept frequency generation oscillator 6, and the period when a modulated light signal is high-level, i.e., the period which stops the drive of a piezoelectric transformer 2, is made to hold so that it may not change, even if the tube electric current Io

of the 1st cold cathode tube 3 falls the signal of the analog quantity which is the output of an integrating circuit 21. For this reason, when the drive of the 1st piezoelectric transformer 2 is made to resume again, without the frequency oscillated by VCO22 changing, it can drive on the same frequency as the frequency before a halt.

[0025] Moreover, this modulated light signal is inputted into the EMBE lobe generating circuit 12. The example of an internal circuitry of this EMBE lobe generating circuit 12 is shown in drawing 6 . This circuit consists of a switch, a constant current source, and a capacitor, if a modulated light signal is set to a low level, since ON and SW4 turn off, SW3 will be charged by Capacitor Cenv from a constant current source, and since OFF and SW4 turn [SW3] on if a modulated light signal becomes high-level, the electrical potential difference of Capacitor Cenv discharges from a constant current source. Therefore, the output of the EMBE lobe generating circuit 12 becomes the trapezoidal wave Venv to which the reversal wave of a modulated light signal had an inclination in a standup and falling. The trapezoidal wave Venv outputted from this EMBE lobe generating circuit 12 Since it is inputted into the 1st comparator 15 (refer to drawing 3) of the 1st drive circuit 7, and the integrating circuit 23 (refer to drawing 5) of the driver voltage control circuit 11 (refer to drawing 4), Since the time of the 1st and 2nd transistors Q3 being turned on from the condition of OFF and the duty when being turned off from the condition of ON are made fluctuated gradually The half wave sinusoidal voltages Vd1 and Vd2 of two phases of the 1st and 2nd piezoelectric transformers 2 are modulated by the EMBE lobe of a trapezoidal wave. This wave form chart of operation is shown in drawing 8 . Thus, since the harmonic content of the drive frequency added to a piezoelectric transformer 2 is restricted as the result of having modulated Vd1 and Vd2 into the EMBE lobe of a trapezoidal wave, the parasitic oscillation of a piezoelectric transformer 2 is oppressed and generating of the audible sound of a piezoelectric transformer 2 or the support device 10 can be reduced. In addition, since the output Venv of the EMBE lobe generating circuit 12 is inputted into the master block 24 and the slave block 25, respectively, all modulated light periods synchronize.

[0026] From the above explanation, with the combination of one master block 24, one or more slave blocks 25, and one modulated light block 26, the drive circuit of the piezoelectric transformer which carries out juxtaposition lighting of two or more cold cathode tubes 3 efficiently at stability can carry out the synchronous drive of drive frequency and the modulated light frequency, and can also reduce generating of audible sound.

[0027] Next, the gestalt of other operations of this invention is explained. About the example shown in drawing 2 , it is equivalent to drawing 1 except the point that the modulated light signal which the EMBE lobe generating circuit 12 of drawing 1 is removed, and is outputted from the modulated light circuit 9 is inputted into the driver voltage control circuit 11. This can be offered as a drive circuit of the piezoelectric transformer which makes stability turn on efficiently two or more cold cathode tubes 3, when the audible sound generated while driving the load does not become a problem.

[0028]

[Effect of the Invention] I hear that a flicker does not occur and there is the 1st effectiveness, when carrying out juxtaposition lighting of two or more cold cathode tubes 3. drive frequency -- and -- or it is for carrying out the synchronous drive of the modulated light frequency. The amplitude modulation of the tube electric current by coupling of the stray capacity between cold cathode tube 3 in synchronizing all drive frequencies can be lost. Furthermore, since the tube electric current value to which the high pressure at the time of drive initiation and a halt of a piezoelectric transformer 2 flows other cold cathode tubes 3 through coupling by the stray capacity of cold cathode tube 3 by synchronizing all modulated light frequencies is not changed, it can prevent circuit actuation becoming unstable.

[0029] Since the 2nd effectiveness is controlled so that all the tube electric currents become fixed even if it carries out the synchronous drive of all the drive frequencies, I hear that brightness becomes fixed and it has it. Since there is dispersion in the resonance frequency of a piezoelectric transformer 2, a pressure-up property, and the voltage-current property of a cold cathode tube 3, only by synchronizing drive frequency, each tube electric current value comes apart, and produces a brightness difference. In order to absorb these dispersion, the peak value of the driver voltage of a piezoelectric transformer 2 is

controlled, and brightness can be fixed by making the tube electric current regularity.
[0030] When two or more juxtaposition lighting of a tube length's long cold cathode tube 3 is carried out, I hear that the 3rd effectiveness can reduce increase of generating of the audible sound in an PWM modulated light method, and there is. Since the driver voltage of a piezoelectric transformer 2 is low, the harmonic content by the time-sharing drive included in that audible sound can be reduced by reducing a mechanical oscillation rate and the drive frequency of a piezoelectric transformer 2 can be reduced by the EMBE lobe generating circuit 12, and generating of the parasitic oscillation of a piezoelectric transformer 2 can also be reduced. Consequently, the audible sound generated from a piezoelectric transformer 2 and its support device 10 can be oppressed.

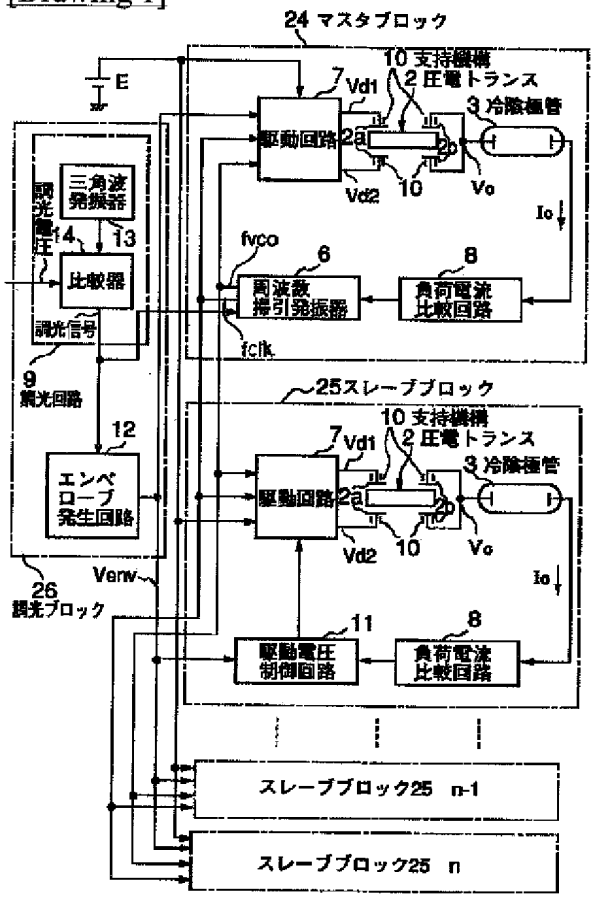
[Translation done.]

* NOTICES *

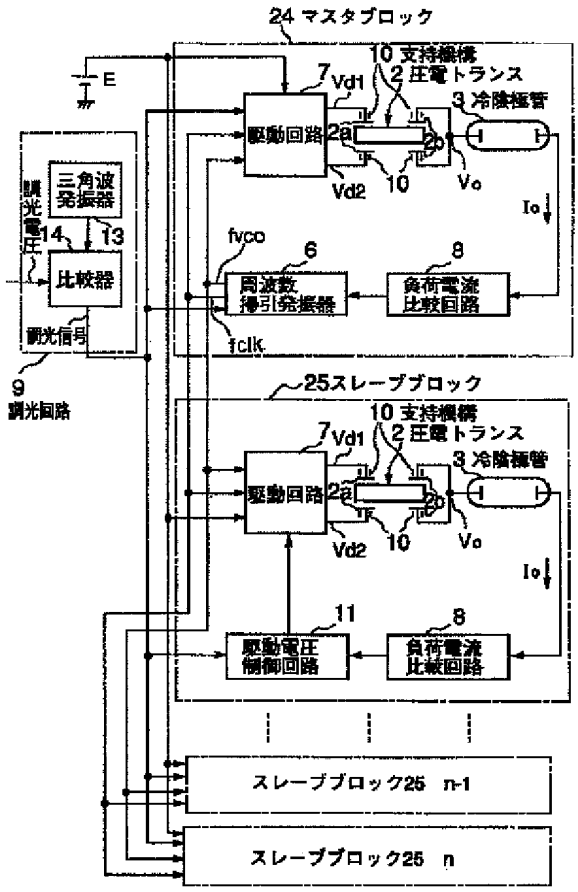
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

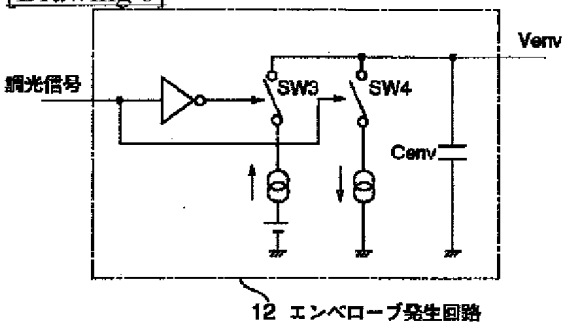
[Drawing 1]



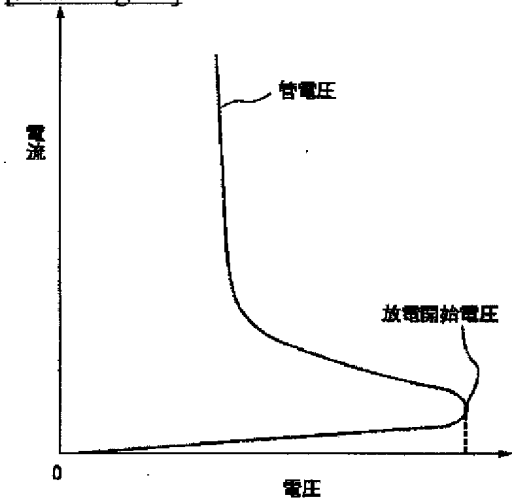
[Drawing 2]



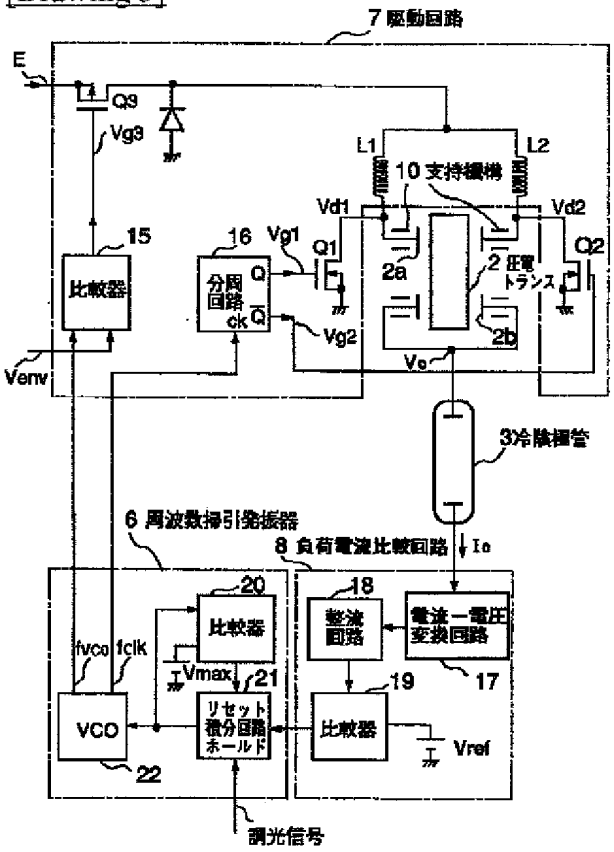
[Drawing 6]



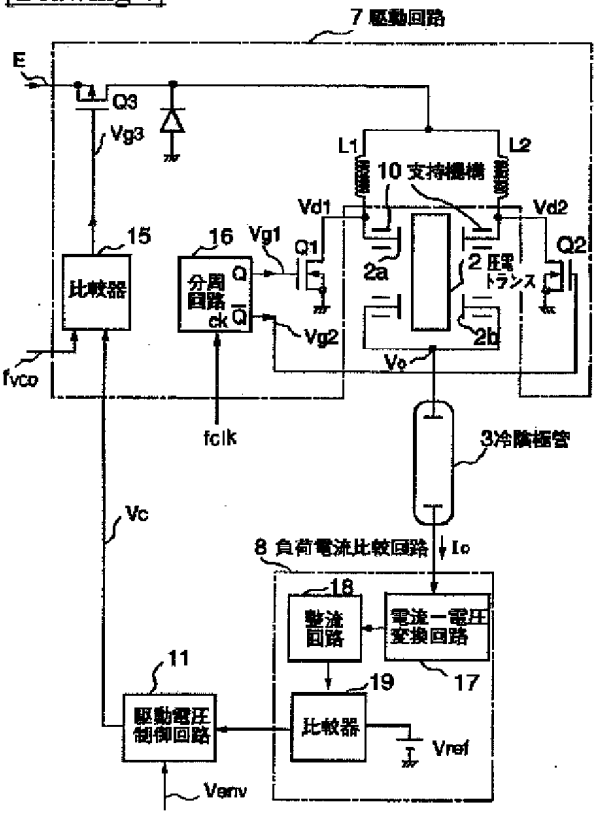
[Drawing 10]



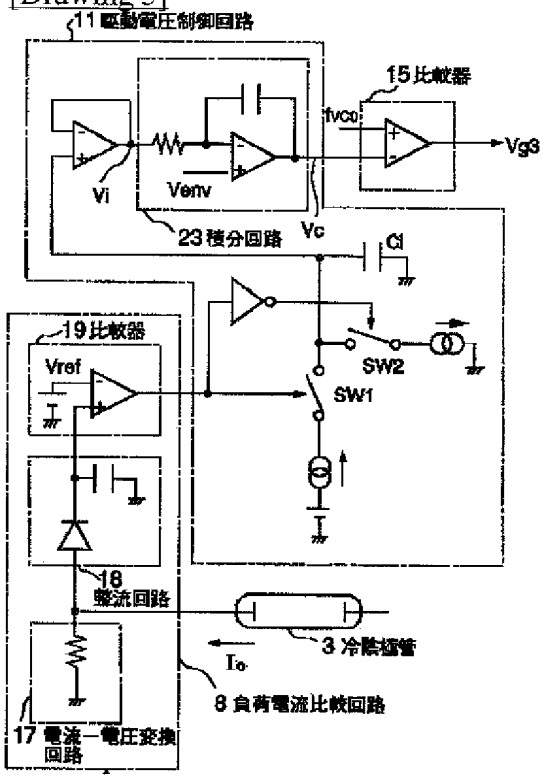
[Drawing 3]



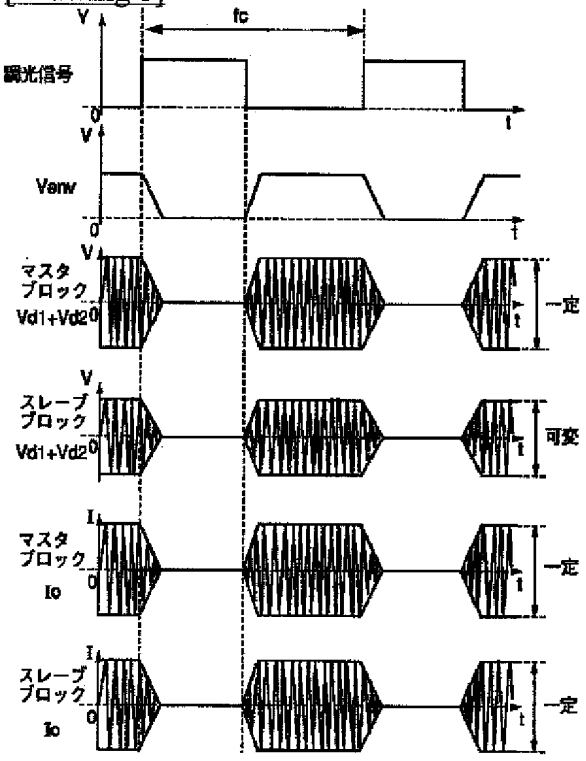
[Drawing 4]



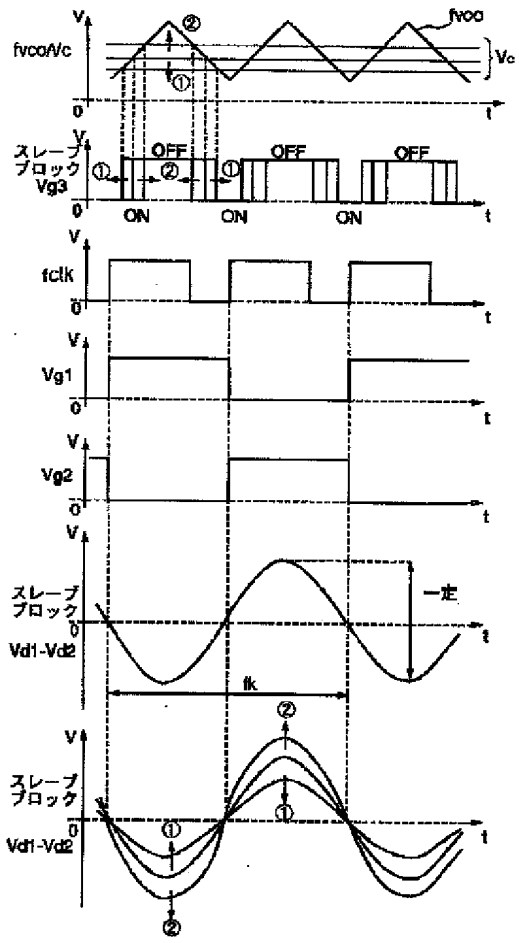
[Drawing 5]



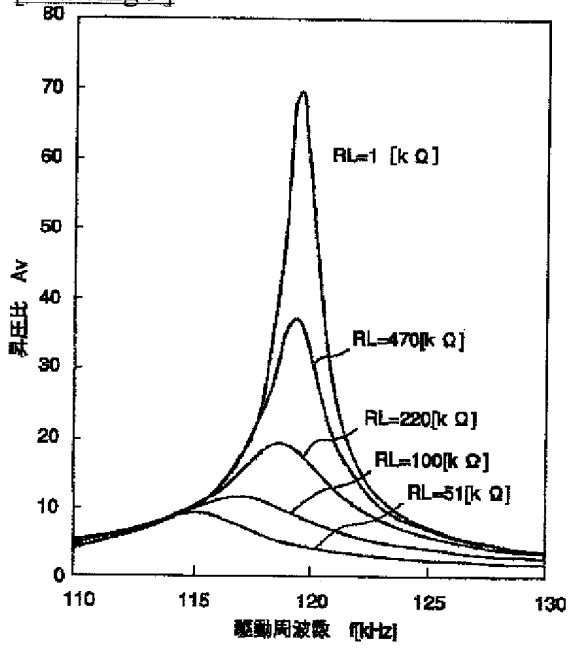
[Drawing 8]



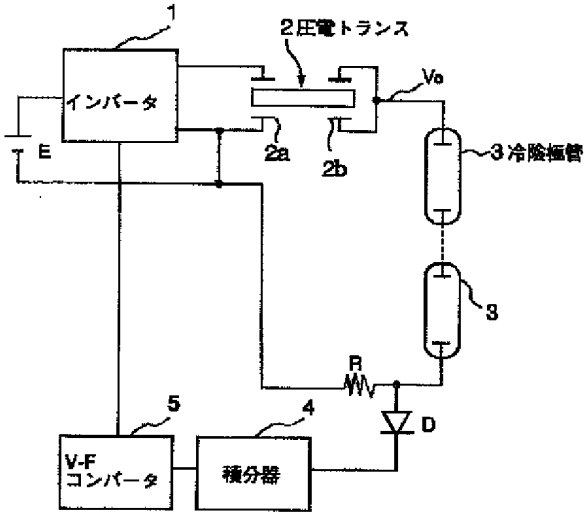
[Drawing 7]



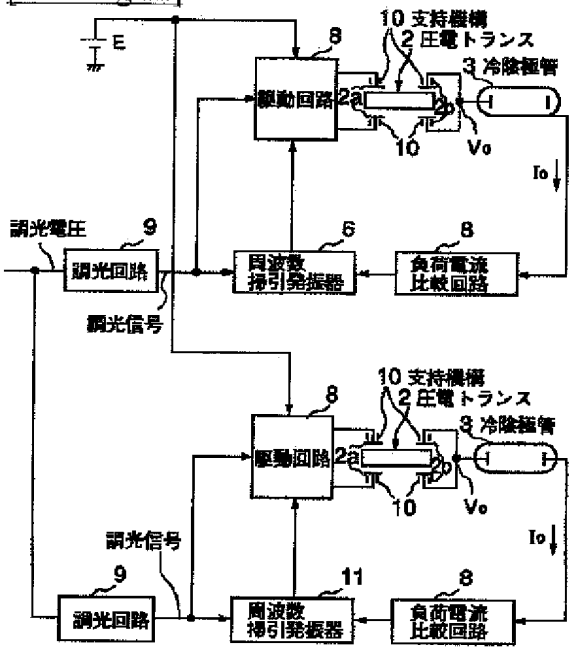
[Drawing 9]



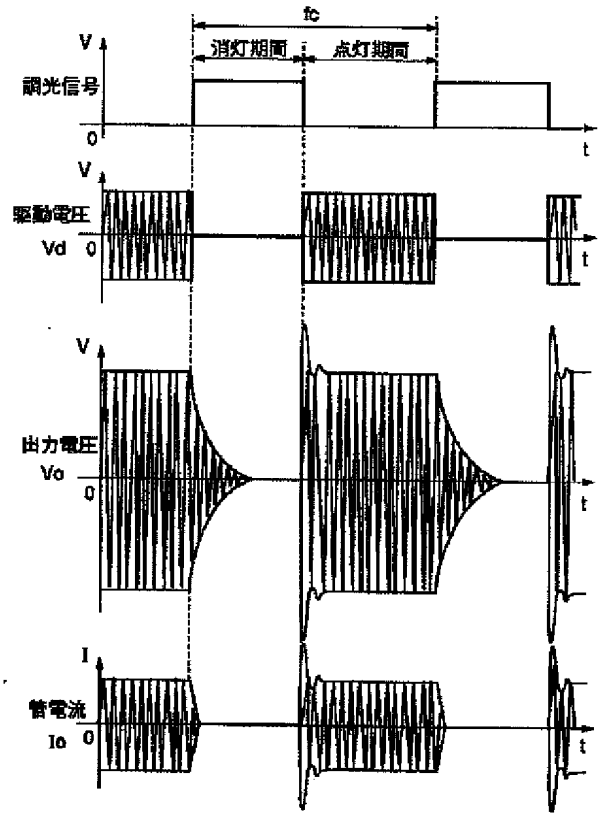
[Drawing 11]



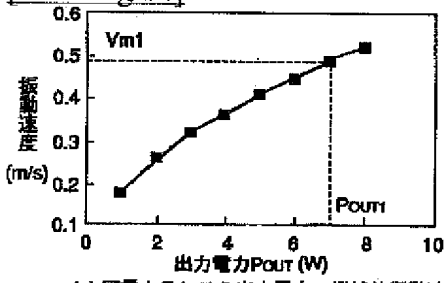
[Drawing 12]



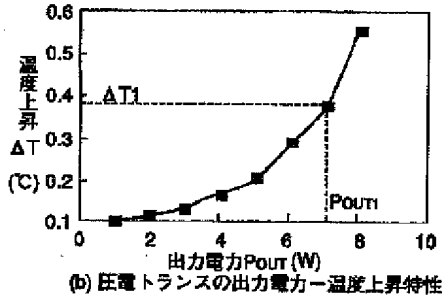
[Drawing 13]



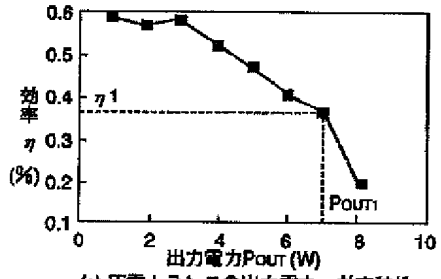
[Drawing 14]



(a) 圧電トランスの出力電力ー機械的振動速度特性

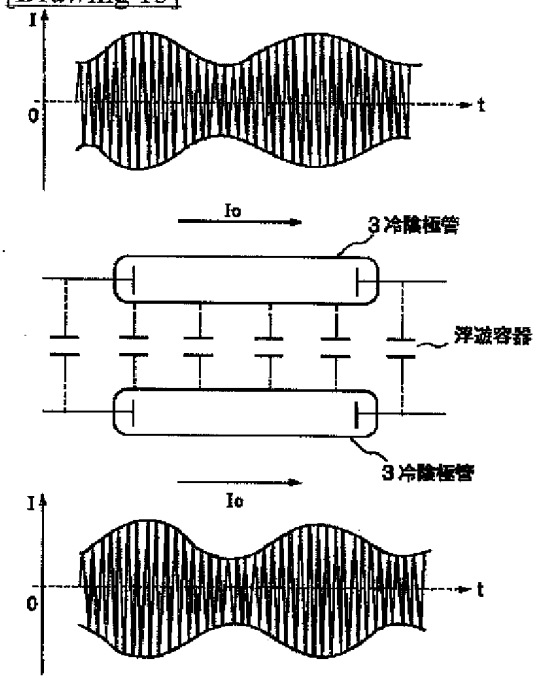


(b) 圧電トランスの出力電力ー温度上昇特性



(c) 圧電トランスの出力電力ー効率特性

[Drawing 15]



[Translation done.]